The Second-Phase Development of the China JinPing Underground Laboratory for Physics Rare Event Detectors and Multi-Disciplinary Sensors

13th International Conference on
Topics of Astroparticle and Underground Physics (TAUP)

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With Inputs and Presentations by
Qiang Du, Jason Detwiler, Davide D'Angelo,
Art McDonald
Gabriel Orebi Gann, Nigel Smith, Murdock Gilchriese,
Dongming Mei, Bela Majorovits

at the Town Meeting on CJPL-2

Asilomar, CA, September 12, 2013

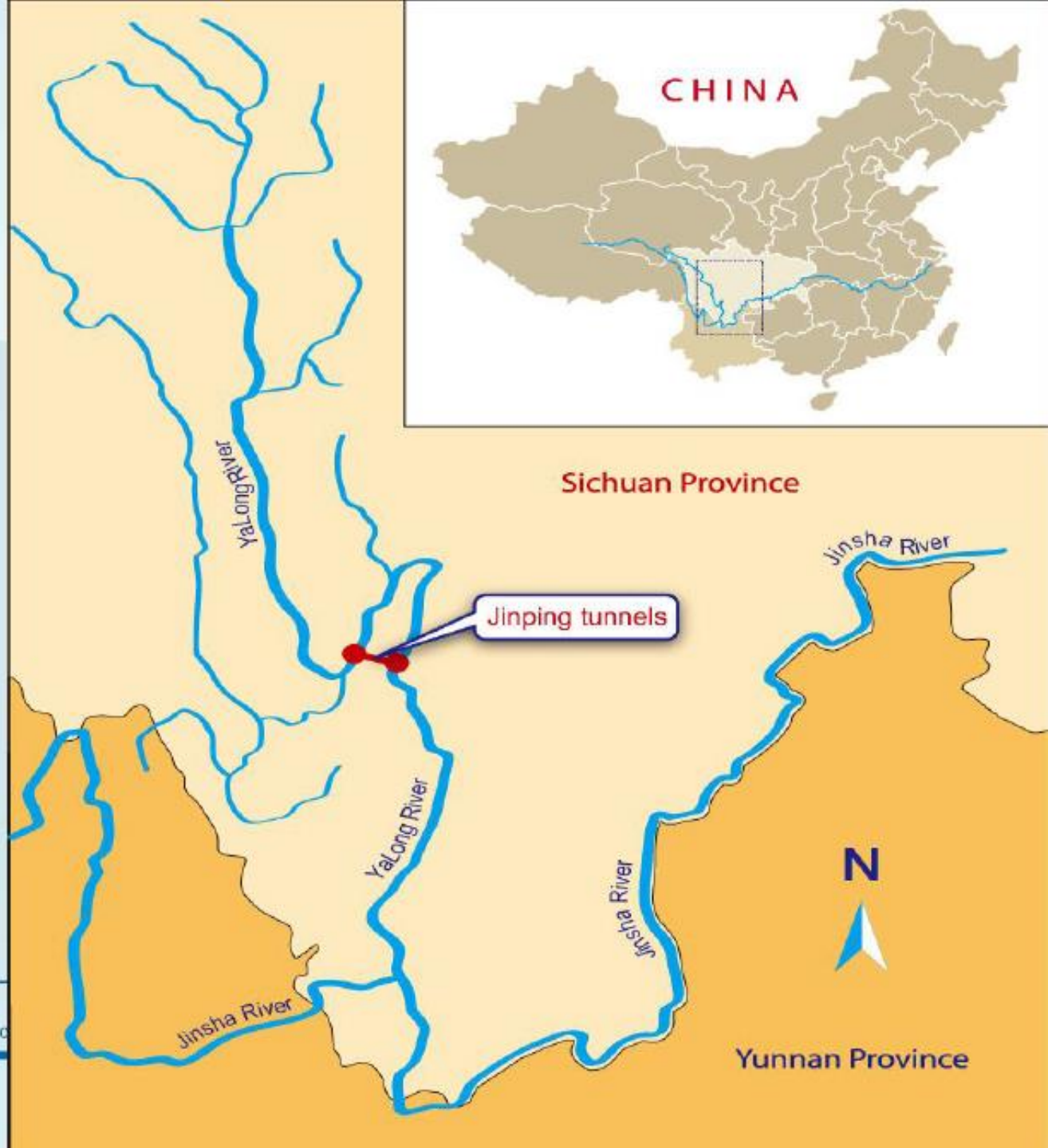
Outline

1. China JinPing Underground Laboratory Extension
   - Physics Dark Matter Experiments
   - Geophysical and Regional/Global Opportunities

2. Site and Infrastructure Needs:
   - Neutrino-less Double Beta Decay
   - Dark Matter Searches
   - Scintillation Detectors for Solar Neutrinos
   - SNOLab Experience
   - SURF Lesson Learned
   - Cd Detector for GeoNeutrino
   - SINO-German Cooperation for Ge Detector

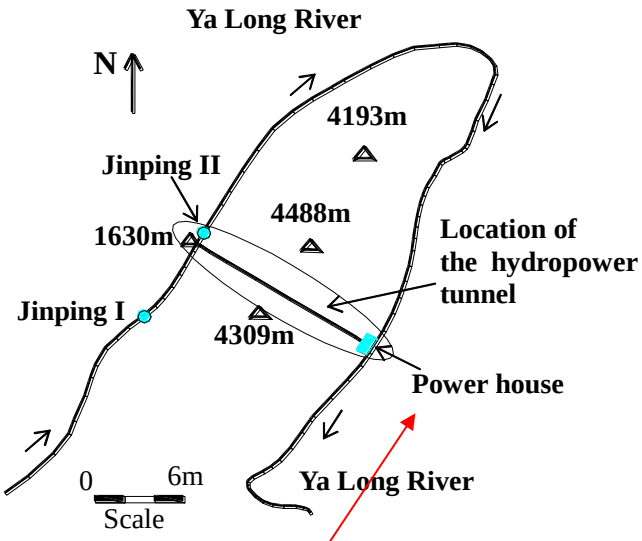
3. Panel Discussions

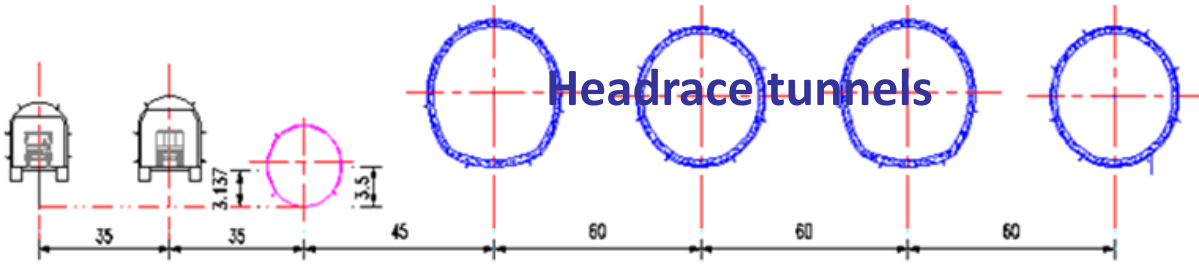
CJPL site

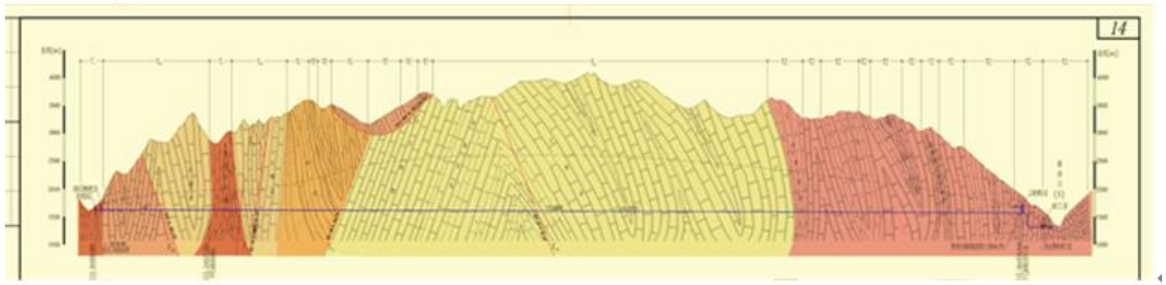


CJPL 中国锦屏地下
China Jinping Undergro

Jining II, China

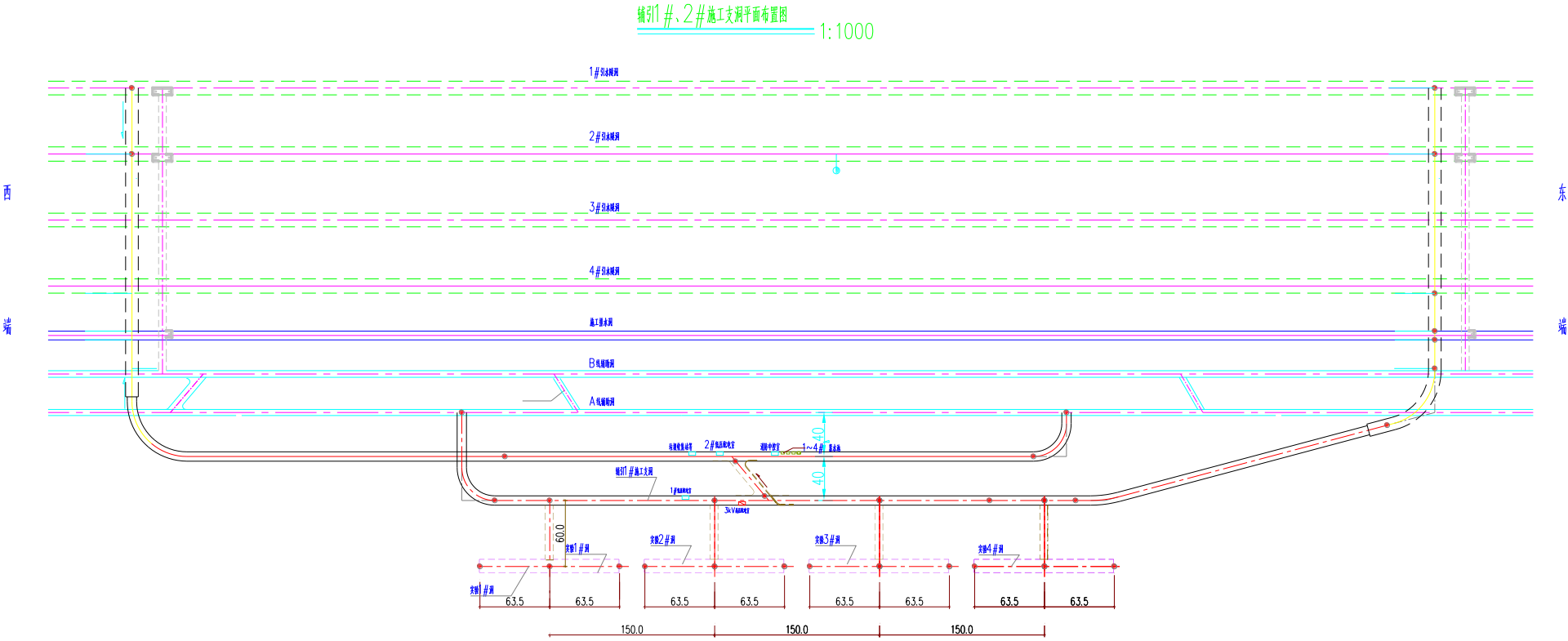




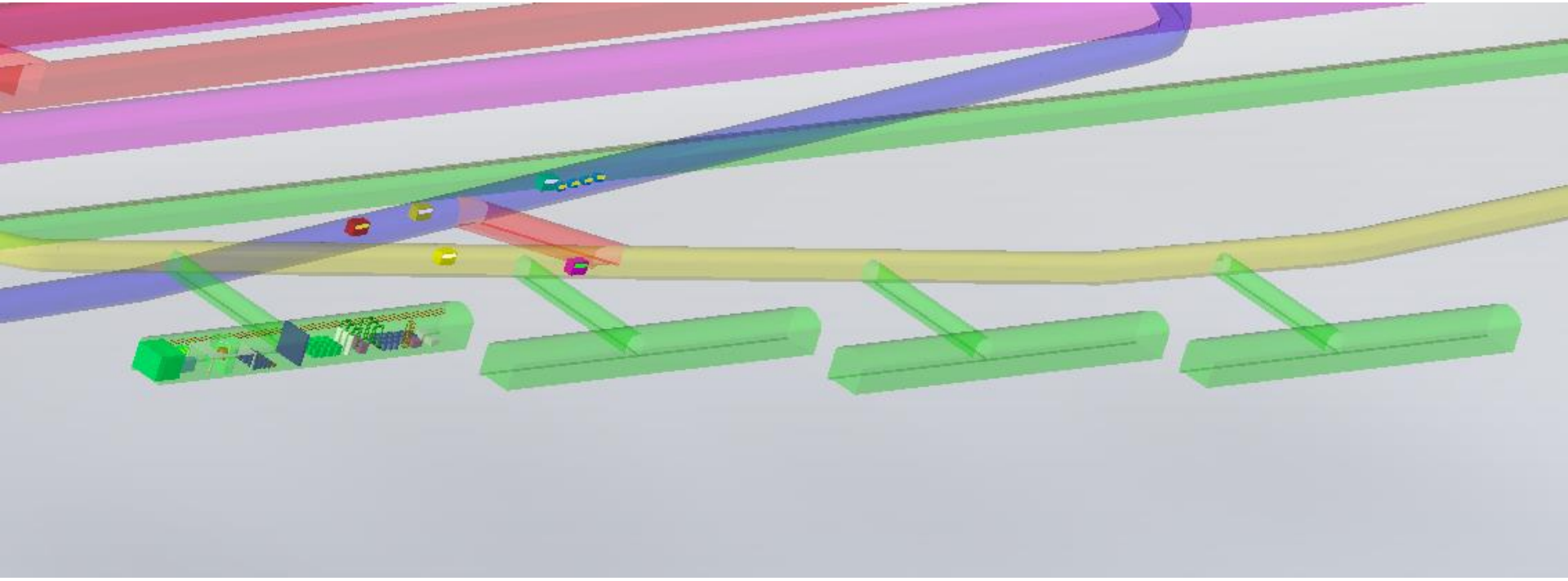


- Seven high pressure tunnels: two auxiliary tunnels, one water drainage tunnel and four headrace tunnels
- Maximum overburden of 2525 m and principal stress of 70MPa by back analysis
- Average length of 17.7km
- Excavated mainly in marble by TBM and D&B

CJPL II

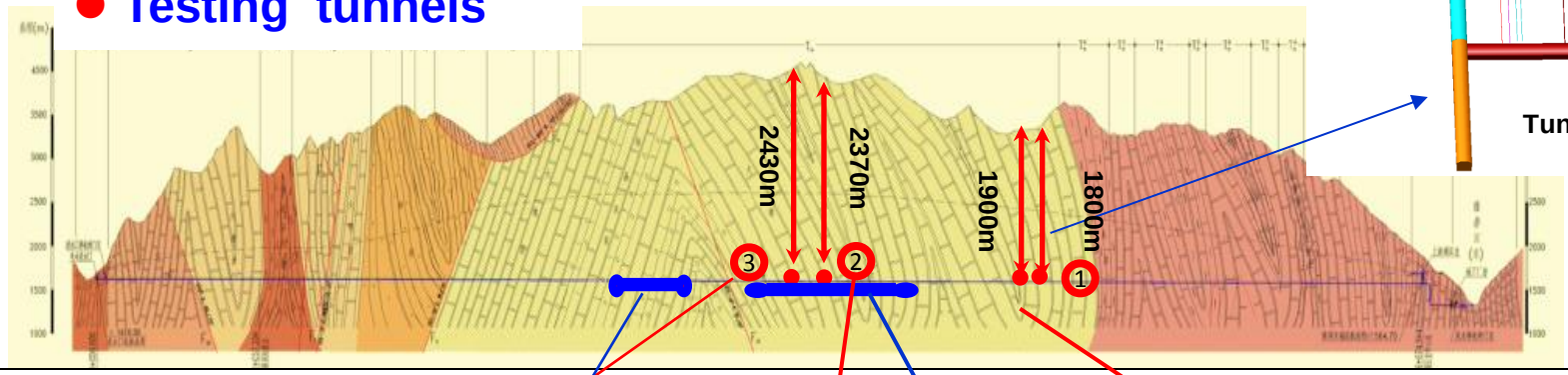

辅引1#、2#施工支洞平面布置图
1:1000
1#引水隧洞
2#引水隧洞
3#引水隧洞
4#引水隧洞
施工排水洞
B线输物洞
A线输物洞
辅引1#施工支洞
2#施工支洞
1~4#施工支洞
40
40
60.0
63.5
63.5
63.5
63.5
63.5
63.5
63.5
63.5
150.0
150.0
150.0

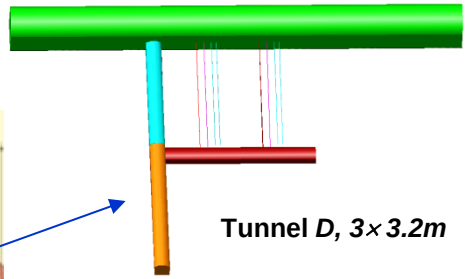
8 rooms of CJPL-II



Rock work volume of 8 x labs	130591 m^3
Concrete work volume	26427 m3
Steel structure	912 T

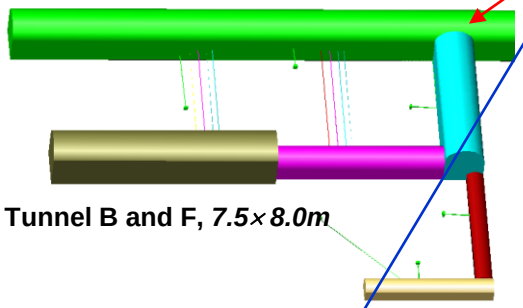
● Testing tunnels



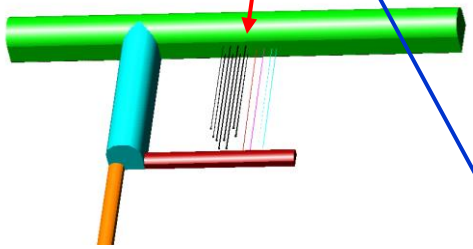


Tunnel *D, 3× 3.2m*

Auxiliary tunnel A

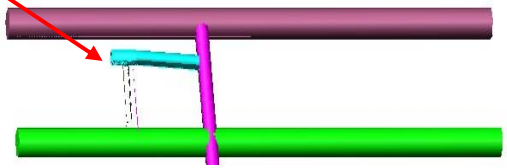


Tunnel B and F, *7.5× 8.0m*

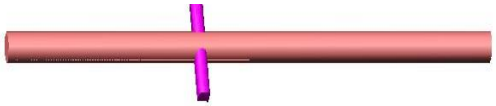


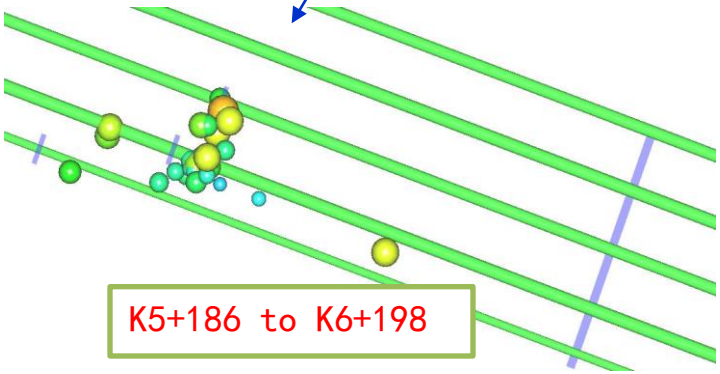
Tunnel *C, 3× 3.2m*

Headrace tunnel no.2, D=13.0m

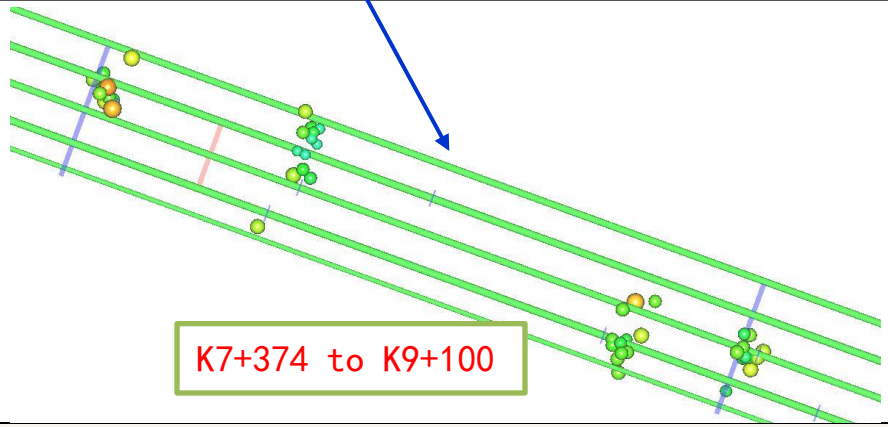


Headrace tunnel no.3, D=12.4m





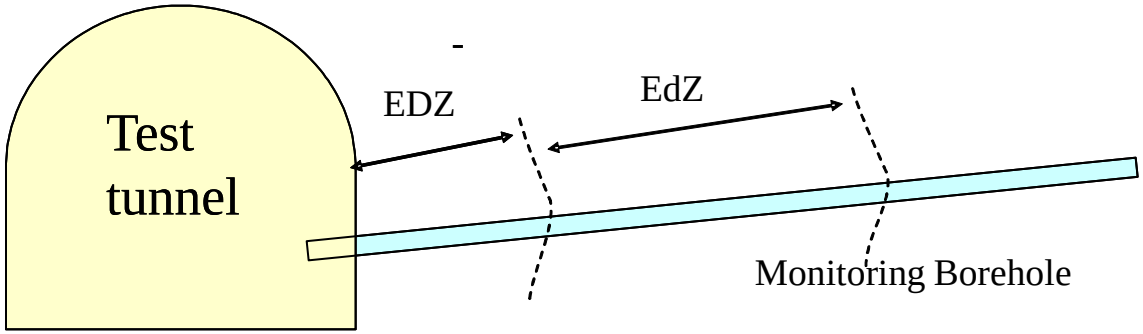
K5+186 to K6+198



K7+374 to K9+100

Evolution of excavation damaged zone

- Excavation Damaged Zone (EDZ): new fractures observed by digital borehole camera, >0.2mm
- Excavation disturbed Zone (EdZ): deformation obviously and micro fractures concentrated, measured by acoustic emission and sliding micrometer



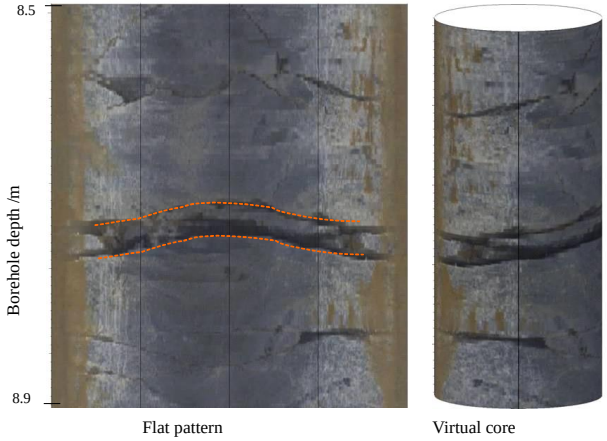
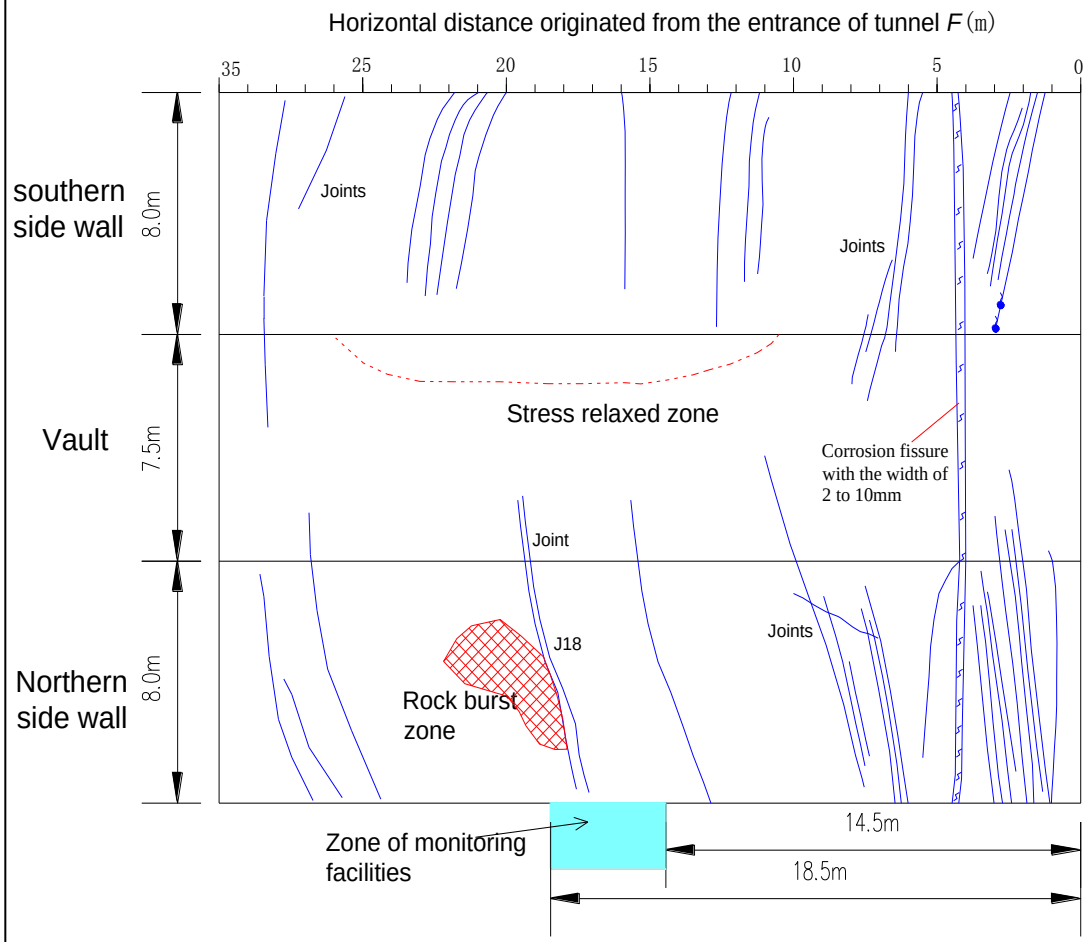
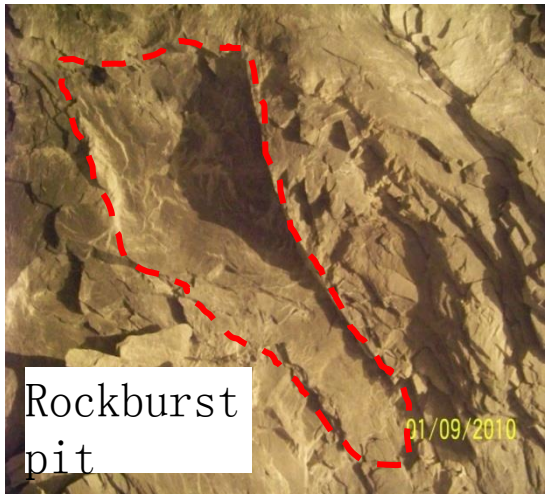


Image of borehole wall and fractures

Description of immediate rockburst



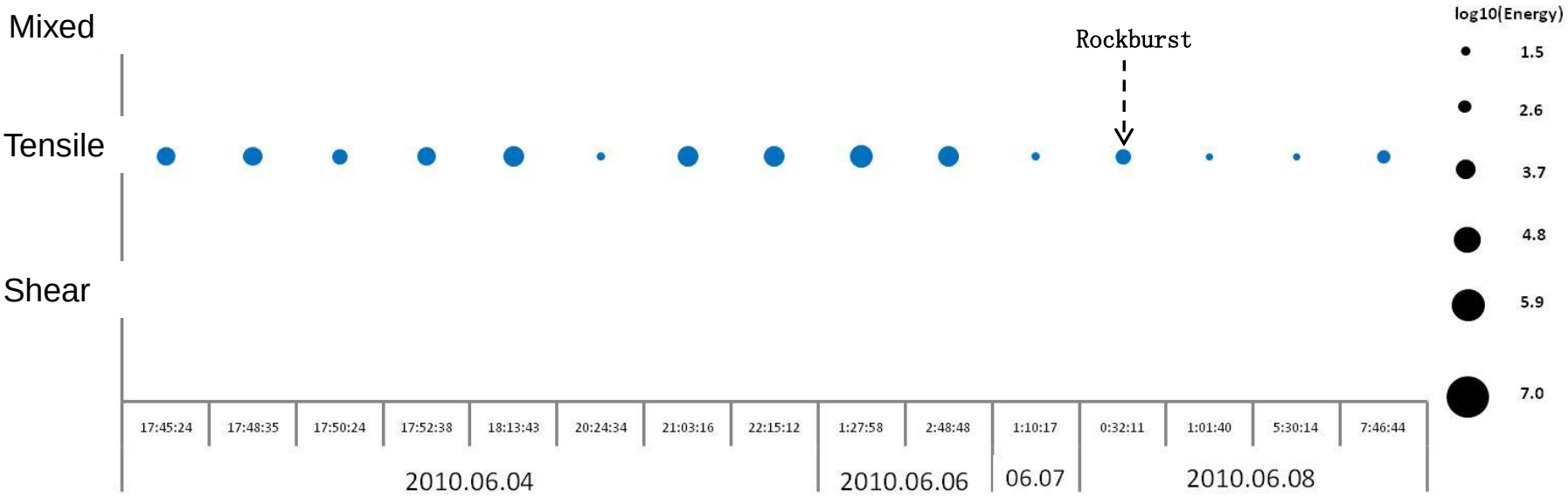
Unfolded geological sketching



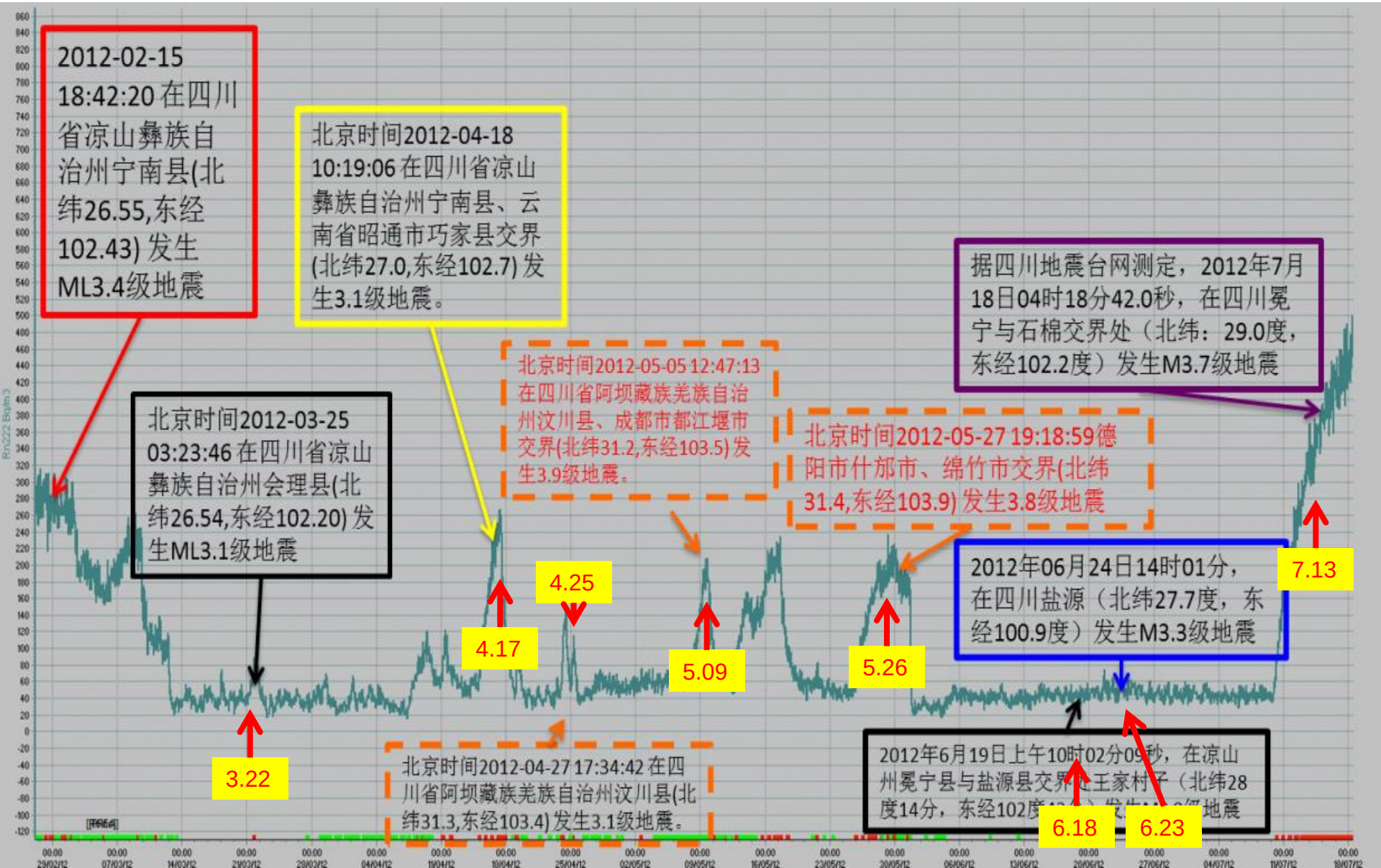
Rockburst occurred on January 09, 2010, with the volume about 6.3 m^3

Evolution mechanism of immediate strain rockburst：tensile failure mainly

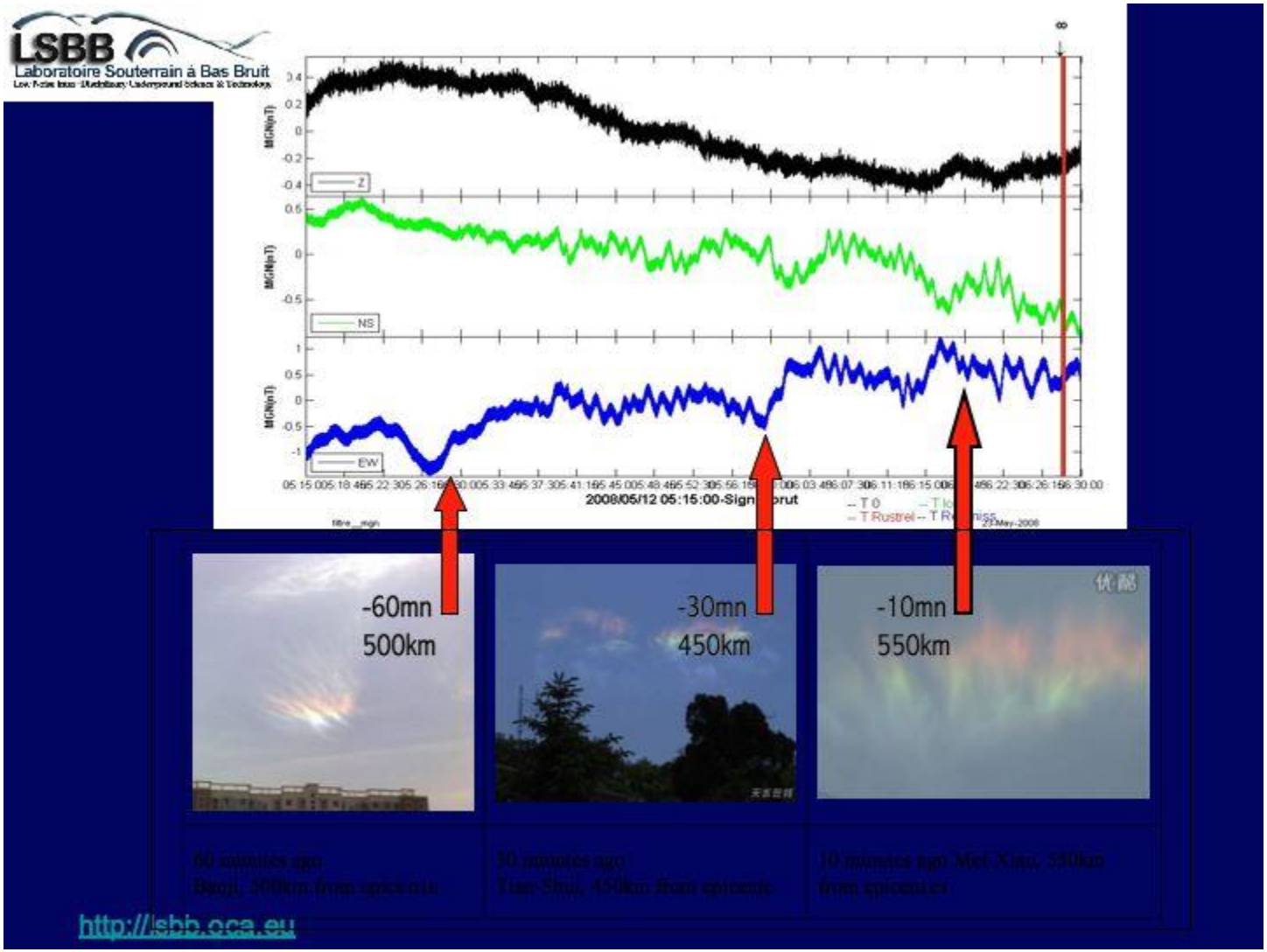
Slight rockburst occurred at northern sidewall to spandrel of 3# TBM headrace tunnel at K11+080-090, June 08, 2010, notch depth: 20-35cm



The relation between radon and earthquake nearby CJPL

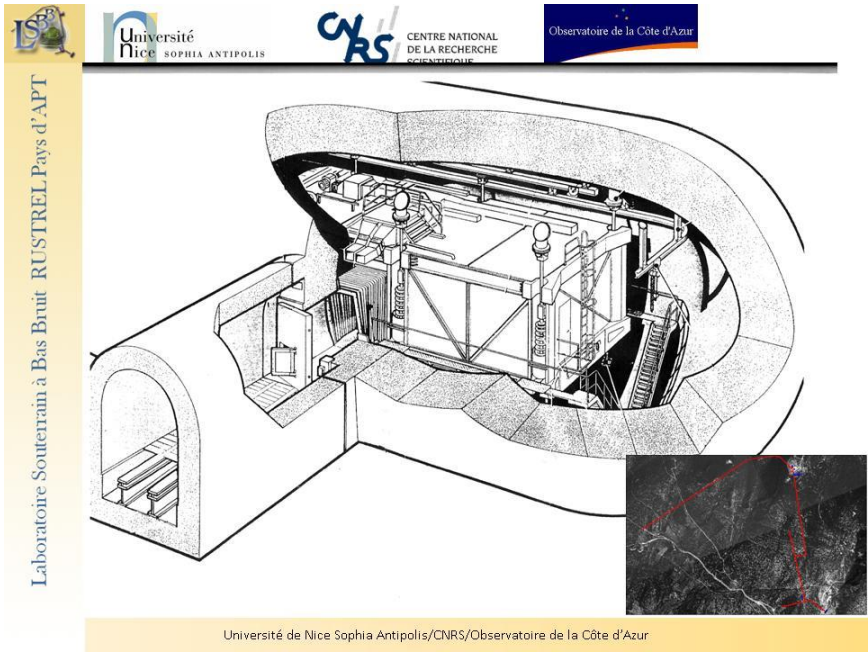


Global Magnetic Signals Detected by $(SQUID)^2$ at LSBB, Rustrel, France



The LSBB "Capsule" with Shielding Has Dimensions: 28 m Long, 8 m in Diameter, 2 cm Steel Walls, 2m Thick Reinforced Concrete

- Waysand 2005 TAUP



and May Co-located with the Next Phase Superheated Liquid Dark Matter Expt. SIMPLE, 1,200 m^3, 2 m Water Shield, 20 Detector Array + DAQ ,

- Tom A Girard, 7/15/2013

SIMPLE IV (superheated liquids) :

2x 1 kg C_2ClF_5 prototypes

(1 rack = 2x recompression systems;
1 system drives 2x 20 kg chambers)

20x 50 kg chambers, w/

- C_2ClF_5, C_3F_8
- $E_{thr}^{recoil} \leq 6$ keV
- low intrinsic backgrounds
- hi- & lo-frequency acoustic instrumentation
- recoil event discrimination

plus

- 2 m surrounding resin-purified H_2O shield
- subterranean siting

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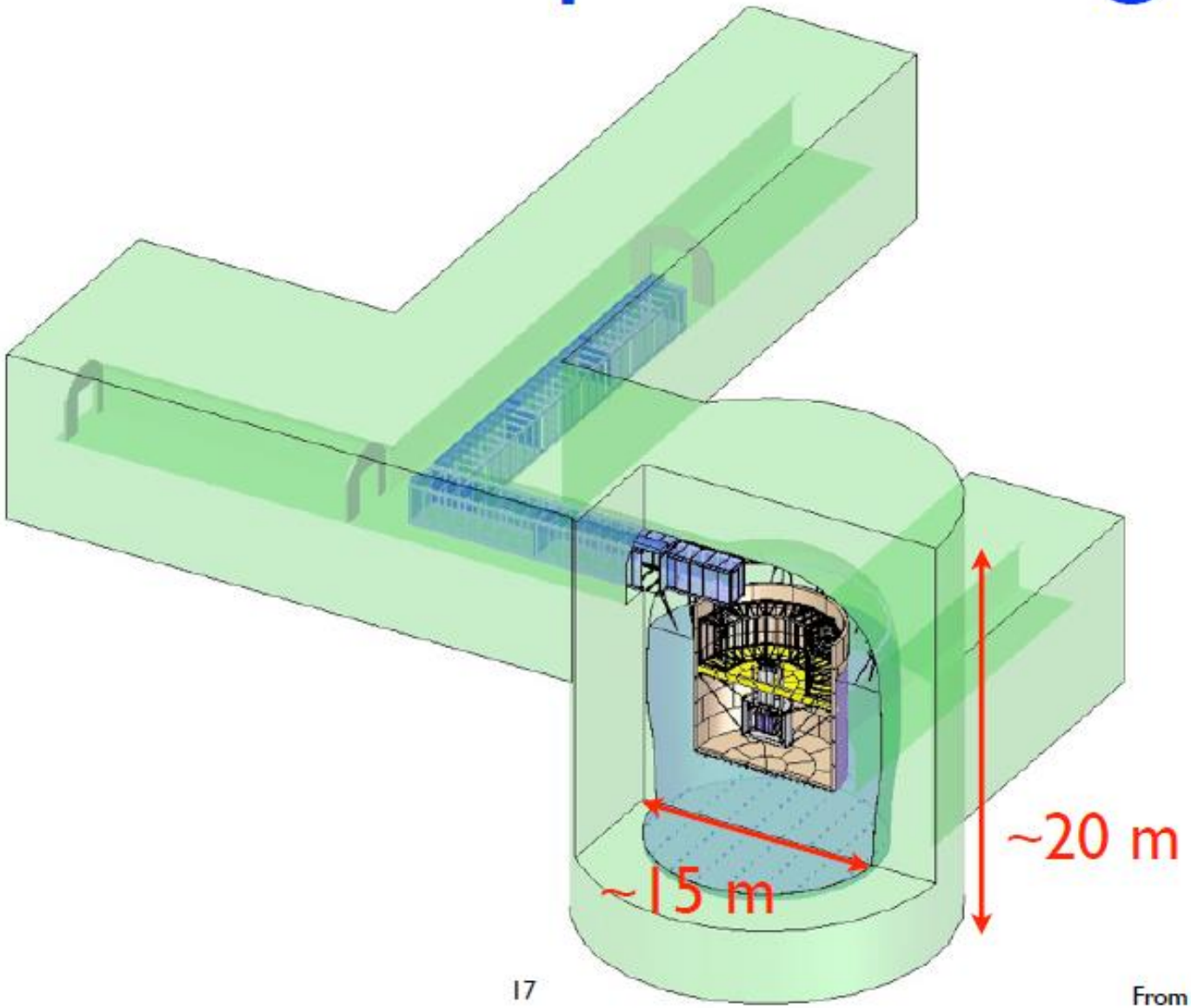
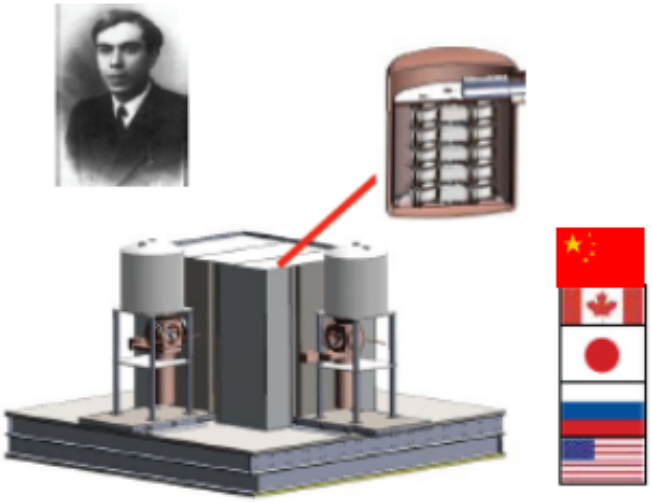
3. Panel Discussions

nEXO Conceptual Design

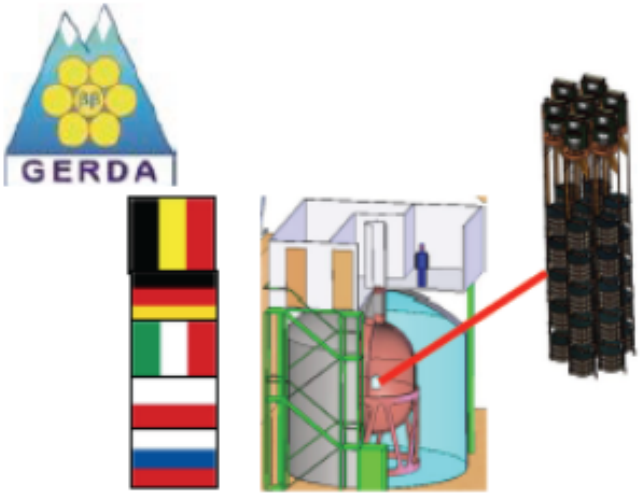


From G. Gratta

MAJORANA / GERDA



- ^{76}Ge modules in electroformed Cu cryostat, Cu / Pb passive shield
- 4π plastic scintillator μ veto
- DEMONSTRATOR: 30 kg ^{76}Ge and 10 kg ^{nat}Ge PPC xtals

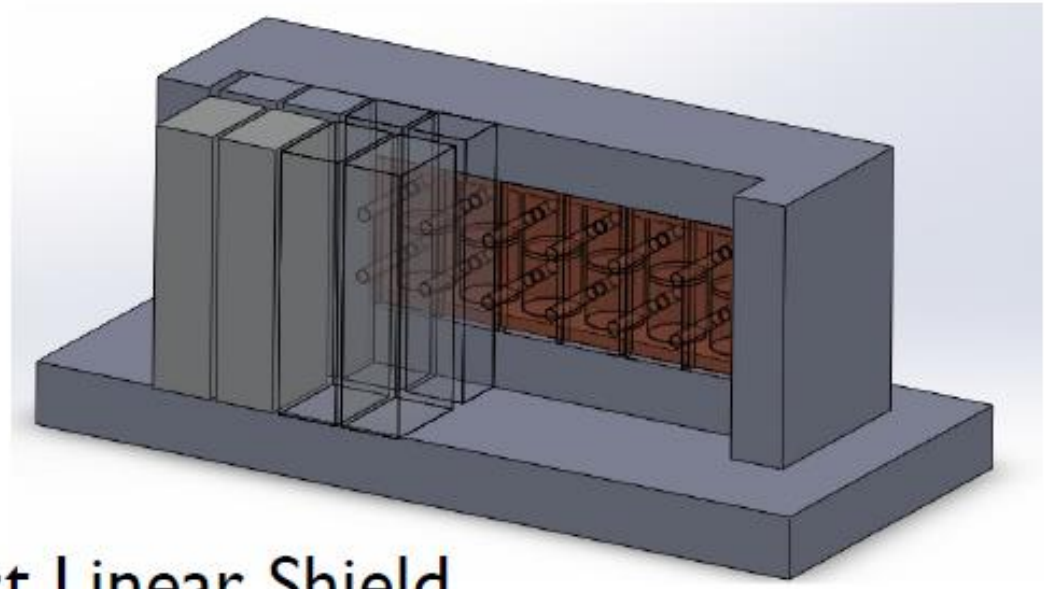


- ^{76}Ge array submersed in LAr
- Water Cherenkov μ veto
- Phase I: ~18 kg (H-M/IGEX xtals)
- Phase II: +20 kg segmented xtals

Joint Cooperative Agreement:

Open exchange of knowledge & technologies (e.g. MaGe, R&D)
Intention to merge for larger scale 1-tonne exp.
Select best techniques developed and tested in GERDA and MAJORANA

Conceptual Designs



Compact Linear Shield

From Davide D'Angelo

Conclusions

- Noble gases are and will be driving dark matter searches at large masses (above LHC limit).
- LXe and (depleted) LAr will both be pursued as complementary approaches.
- 2014: G1 projects coming to a conclusion.
- 2017: G2 projects should perform physics runs.
- 2020: G3 projects at multi-ton scales plan to converge.

thanks for material to Marc Schumann, Laura Baudis, Cristiano Galbiati

Laboratory needs

- Service lines: cooling, network,…
- Standard laboratory services
- Machine shop, chemistry lab, electronics lab,,computing.
- Desiderata:
  - Radon free clean room
  - PMT test facility (above ground)

from Gabriel Orebi Gann

The Road Forward

- **What the Sun can tell us about neutrinos**
  - *Precision pep flux*
  - *Low-energy ^{8}B spectrum*

  } Search for new physics in transition region
  - *Day/Night asymmetry measurement* — Confirm MSW

- **What neutrinos can tell us about the Sun**
  - *CNO flux measurement* — Resolve solar metallicity
  - *Direct pp measurement* — Luminosity constraint

"Gold ring of solar neutrino physics & astronomy"

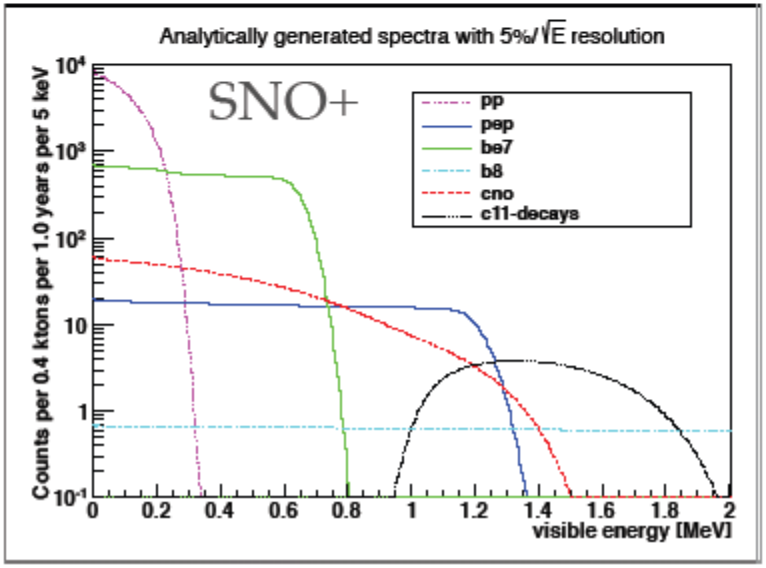
--- John Bahcall

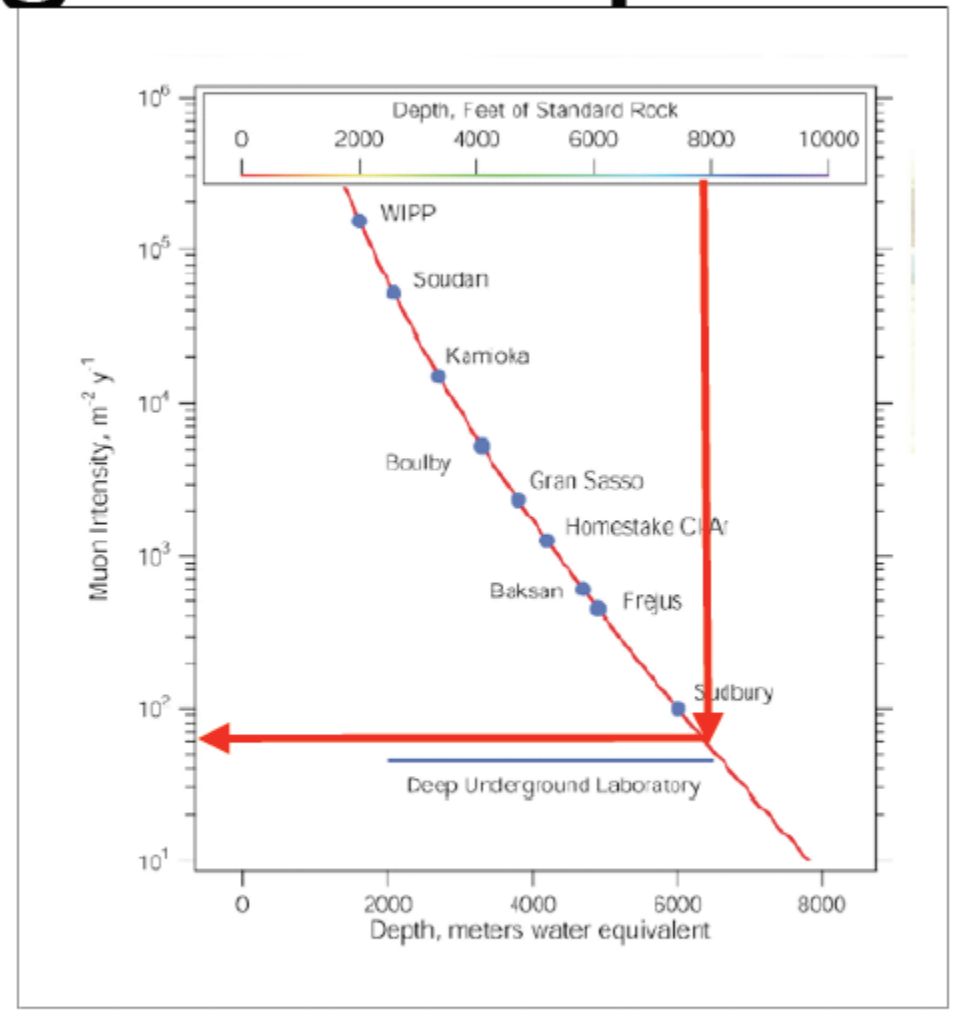
The Advantages of Depth

^{11}C produced by cosmic μ hitting organic molecules

KamLAND: 2700 mwe
Borexino: 3500 mwe
SNO+: 6080 mwe

JinPing: 7500 mwe

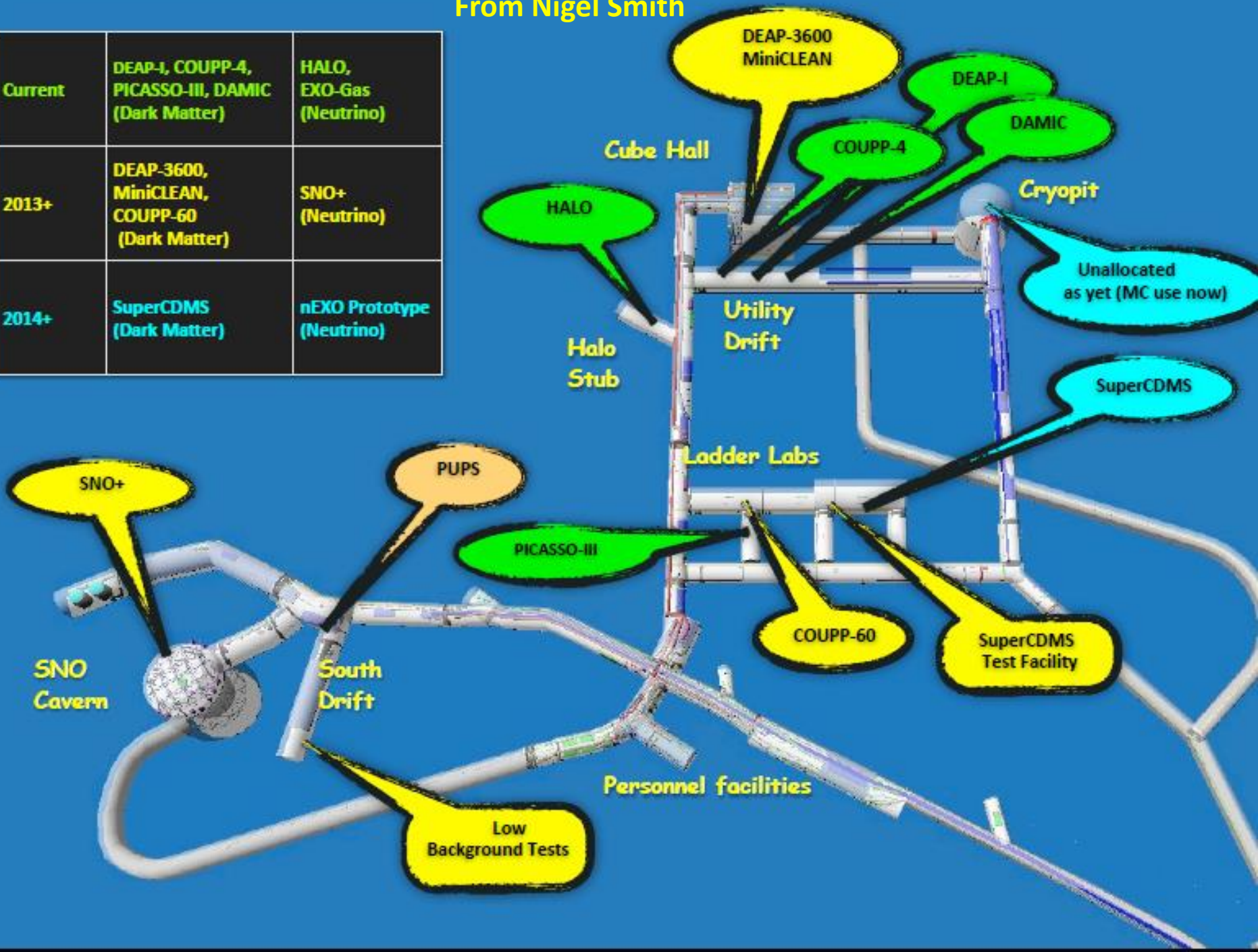




Ultra low cosmogenic backgrounds!

From Nigel Smith

Current	DEAP-I, COUPP-4, PICASSO-III, DAMIC (Dark Matter)	HALO, EXO-Gas (Neutrino)
2013+	DEAP-3600, MiniCLEAN, COUPP-60 (Dark Matter)	SNO+ (Neutrino)
2014+	SuperCDMS (Dark Matter)	nEXO Prototype (Neutrino)



Beyond SURF

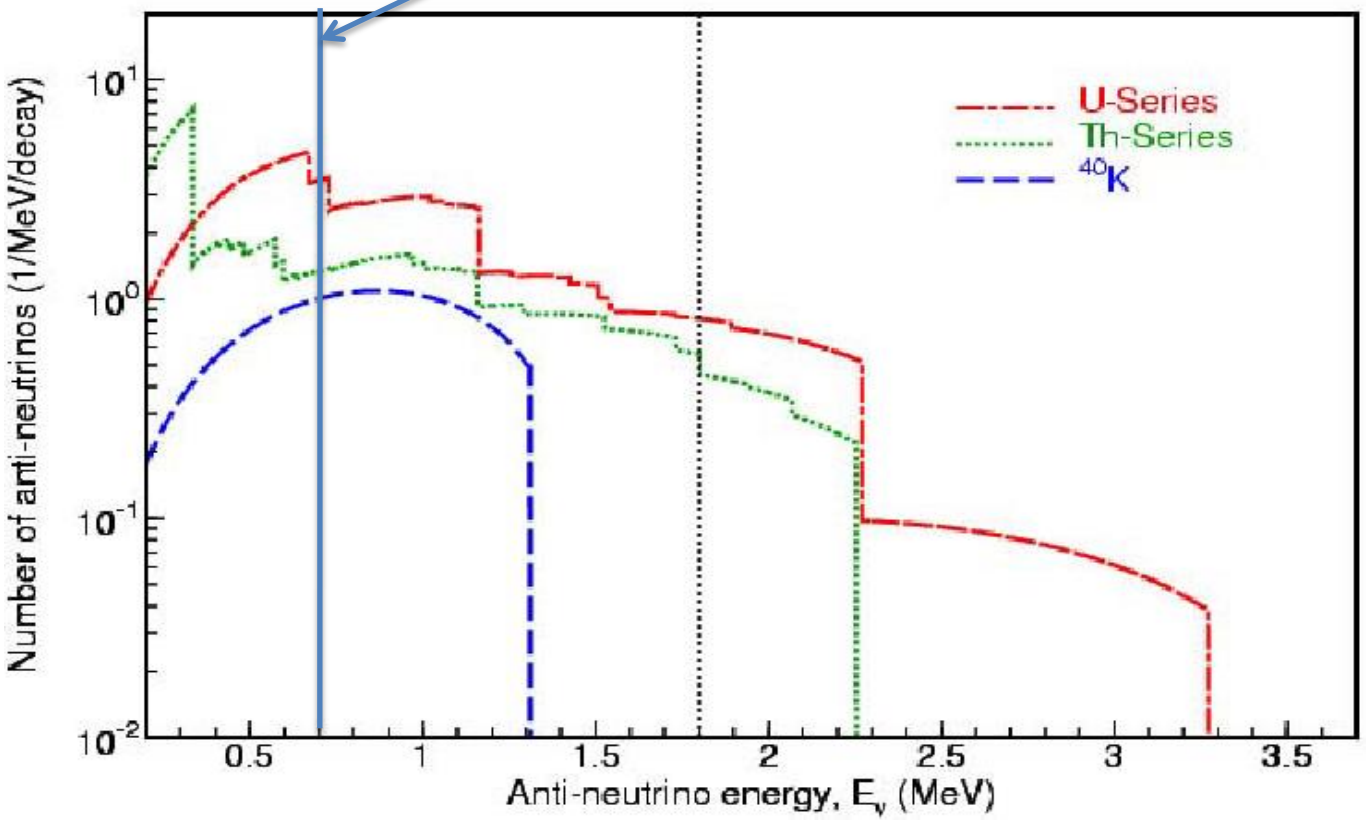
- Design studies for big future experiments were done as part of the DUSEL effort and are documented in http://arxiv.org/abs/1108.0959
- The details of these studies may be of modest use to CJPL expansion
- Of possibly more relevance is the process that was used
  - Considerable interaction with potential experiments
  - Workshops, studies, etc
  - Easy to organize, but requires in – house group for continuity and to capture the information
  - Best if on – site but not required

from Dongming Mei

Geo-neutrinos and their detection

Threshold for

$$\bar{\nu}_e + {}^{106}Cd \rightarrow {}^{106}Ag + e^+$$



B. Majorovits (MPI für Physik, München) on behalf of the GDT cooperation

Future plans:

Scientific exchange

Planned common activities:

Measure muon induced neutrons at shallow (and deep ?) underground site (Jingping)

Low background ASIC development for HPGe at cryogenic liquids

Evaluation of needs for next generation experiment

Next symposium :

Tsinghua university in Beijing from May 12 to May 16, 2014
Contact for info:
Dr. Iris Abt (isa@mpp.mpg.de)
Prof. Qian Yue (yueq@mail.tsinghua.edu.cn)

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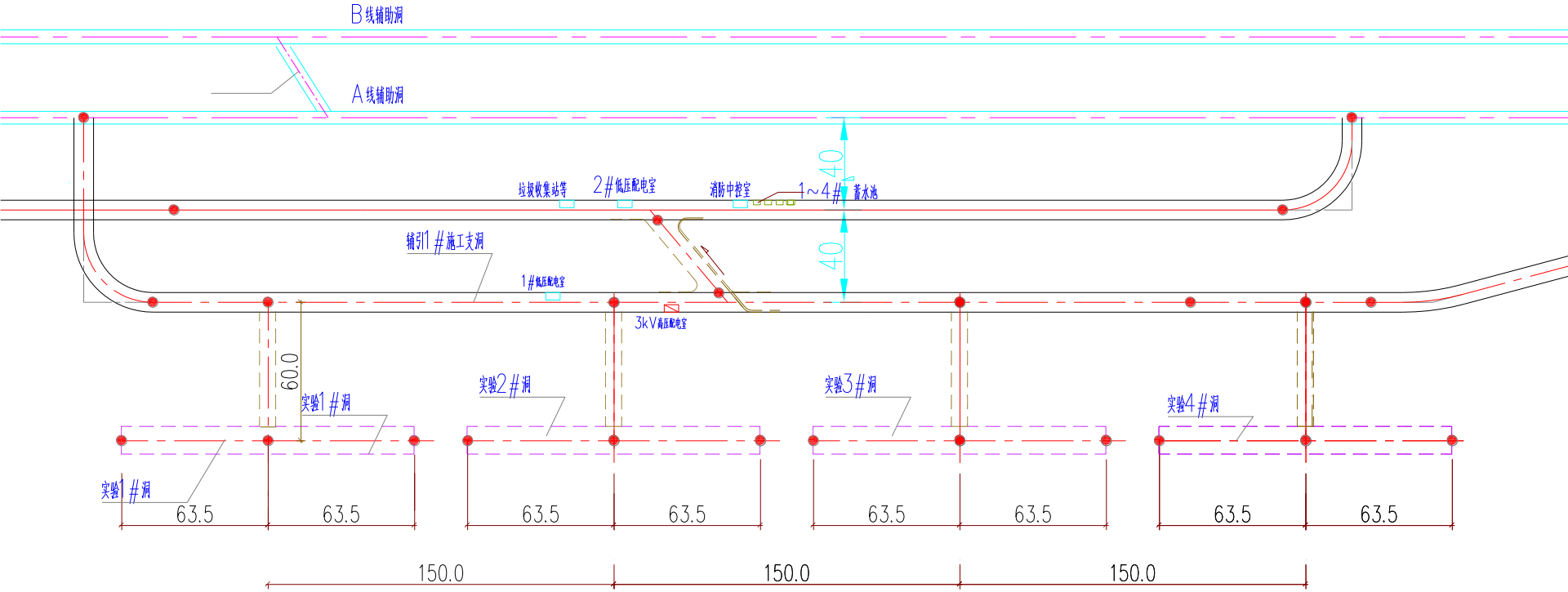
3. Panel Discussions

Panel Discussions: Xiangdong Ji, Muldock Gilchriese, Nigel Smith, Wick Haxton, Art McDonald, …

CJPL Rock Background

(Unit：Bq/kg)	**K-40**	**Ra-226 (609keV)**	**Th-232 (911keV)**
JinPing Rock Sample	< 1. 1	1.8±0. 2	< 0. 27
Beijing Normal Ground Level	~600	~25	~50

CJPL II



- More Space
  - 4000m³ -> 96,000m³
  - 60kVA -> 600kVA
  - 40m³/h -> 5000m³/h
- More Project
  - CDEX-1T
  - PandaX-1T
  - .....

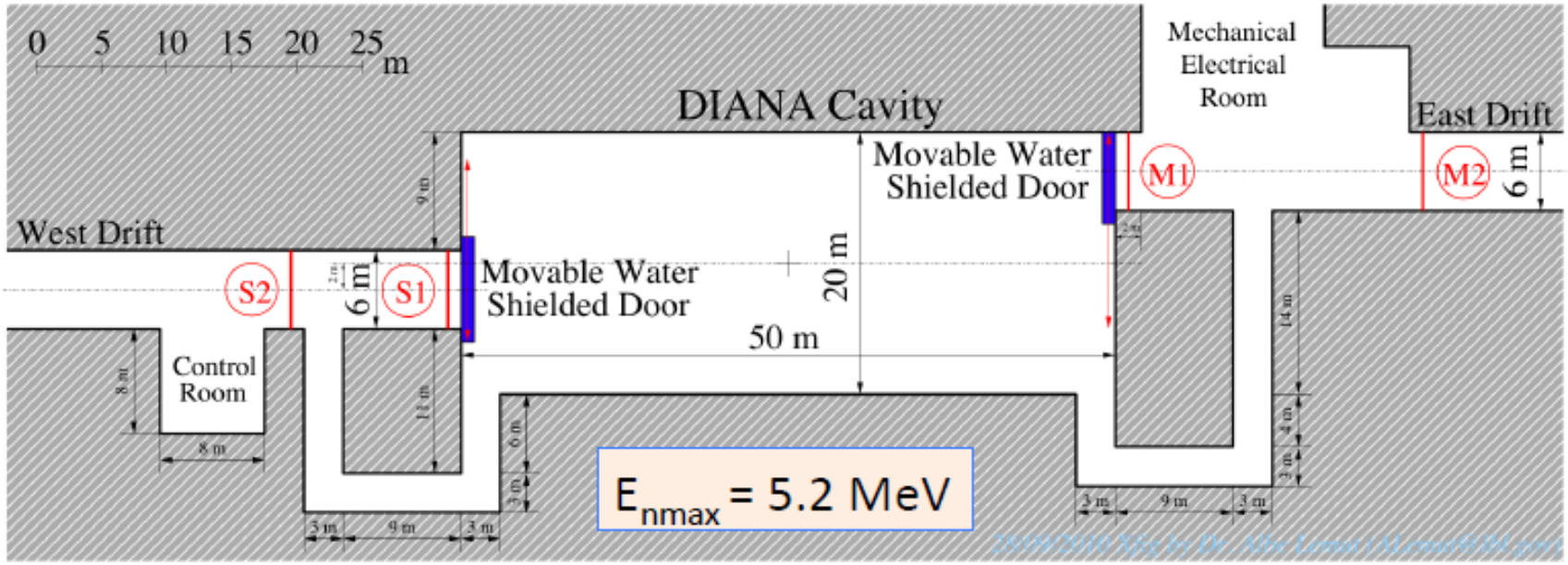
Plan of Civil Work

- Jun. 2013 ~ Dec. 2013 : Concept Design
- Jan. 2014 ~ May. 2014 : Detail Design
- Jun. 2014 ~ Oct. 2014 : Tender Process
- Nov. 2014 ~ Dec. 2014 : Contract and approval
- Jan. 2015 ~ May. 2015 : Dig and Support
- Jun. 2015 ~ Sep. 2015 : Concrete work
- Apr. 2015 ~ Jun. 2015 : Flesh air tube work
- Oct. 2015 : Civil work Accept Test
- Nov. 2015 ~ Jun. 2016 : Infrastructure work

BackUps

Backup Material

Modified Cavity Layout Proposed to DUSEL Project



The LM1 entrances shielding has been designed such that any beam induced radiation outside (at M2 at S2) will be **BELOW THE NATURAL RADIATION LEVELS** of DUSEL ($\Phi_n = (2.3 \pm 0.8) \times 10^{-6}$ n/(cm^2 s), $\Phi_\gamma = (0.32 \pm 0.10)$ γ/(cm^2 s), after D. Mei *et Al.*, Astropart. Phys, Vol. 34 (2010) 33 - 39).